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WITNESS my hand this
Sixteenth day of December 2003

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Title

INTERCEPTION MISSILE AND METHOD OF INTERCEPTION

Field of the Invention

The present invention relates to missile defence systems. In particular, although not exclusively, the invention relates to interception missiles and interception methods for defending against ballistic missiles.

Discussion of Prior Art

There are a number of fundamental difficulties involved in the interception of an incoming enemy ballistic missile with a conventional interception missile or similar kill vehicle. Engineering a hit-to-kill interception missile that can achieve intercept with any consistency is problematic, principally because of the high converging speed of the target ballistic missile and the interception missile. The latter must be in exactly the right place at the right time to achieve a direct hit on the target missile.

Typical conventional interception missiles have a relatively small cross-sectional diameter which must intercept either the front of the incoming enemy missile or its side, which is a very small area. If the interception missile includes a warhead that is detonated before projected impact, fragmentation delivered by the interception missile can increase the chance of a hit on the enemy missile. However, current fragmentation techniques, which basically the detonation of an explosive charge, do not provide a homogenous fragmentation pattern. In fact the fragmentation pattern of a simple detonation is random and extremely haphazard.

The fragmentation pattern of a simple detonation is depicted in Figure 1 of the accompanying drawings. In this regard it should be noted that the diagrams presented in this specification are necessarily not to scale, and are provided merely by way of representation. Simple fragmentation tactics do not ensure a hit on an enemy missile 10 that passes through an outwardly expanding fragmentation radius 12. This means that the fragmentation radius of a detonation cannot be relied upon to increase the allowable margin of error in interception time and position of the interception missile or kill vehicle.

In missile interception, a guaranteed kill is the ultimate goal. It would be advantageous if an interception missile could be permitted to miss its target and yet still have an excellent chance of multiple projectile impacts within a specified radius. Generally the speed of both the incoming missile and the interception missile make tracking the incoming missile to within a hit-to-kill margin of error, extremely difficult. Present missile tracking technologies are quite sophisticated, however the problem remains that often quite significant changes in the trajectory of the interception missile are required but are difficult to execute.

Divert propulsion technologies are limited in their effect due to the size and weight of the interception missile, as well as its speed. The angle an interception missile will be caused to change trajectory, due to mass being ejected perpendicular to its velocity, is based on the familiar conservation of momentum equation: $m_1v_1 = m_2v_2$. The capability of current divert propulsion systems is severely limited by the very small mass ejected in order to affect changes in trajectory.

Modern ballistic missiles, such as long-range ICBMs, can be designed to deploy multiple decoys and live warheads during flight. Accordingly, an interception missile for defeating this threat must employ a myriad of sensory technology in order to select or discriminate the live warheads from the decoy warheads. There is not believed to be any technology currently available to satisfactorily address this threat.

Summary of the Invention

An aim of the invention is to provide a missile defence system that overcomes, or at least addresses, one or more of the abovementioned difficulties.

An aim of certain embodiments of the invention is to provide an interception missile and interception method wherein a greatly improved probability of killing or at least disabling an enemy missile could be achieved without any requirement for a direct hit by an interception missile or kill vehicle, when the enemy missile passes within a predetermined radius of the interception missile.

In the present applicant's earlier International Application No. PCT/AU01/00607 (published as WO 01/90682), there is described a method and apparatus for the directional control of missiles, including missiles for defending against incoming enemy ballistic missiles. This invention represents an improvement over the directional control of hit-to-kill defensive missiles.

In a further International Application No. PCT/AU02/00909 (unpublished) by the present applicant, there is described a method and apparatus for deploying sub-projectiles involving a generally spherical projectile having a multiplicity of barrel assemblies radially disposed from the centre of mass of the projectile and capable of selectively firing sub-projectiles to provide a predetermined pattern of deployed sub-projectiles. This invention provides a compact and lightweight means of delivering substantial fire-power in myriad applications.

It has now been realised that an interception missile or other kill vehicle having a multiplicity of barrel assemblies to deploy projectiles in a generally homogeneous pattern, such as a two dimensional array of projectiles which are separated by no more than a predetermined distance at a pre-selected deployment radius, will provide improved interception performance. In particular, the predetermined distance is less than the cross-sectional diameter of an enemy ballistic missile to be defended against.

It is observed that a missile hitting a stationary projectile at Mach 23, for example, has the same effect on the missile, as would a projectile fired at a stationary missile at Mach 23. The missile system outlined in this specification takes advantage of this fact. If a homogenous, grid-like field of projectiles, in which all projectiles are separated by slightly less than the cross-sectional diameter of the enemy missile, is placed in the path of the enemy missile, the enemy missile cannot pass through the field without impacting on projectiles.

In one broad aspect, the present invention resides in a method for intercepting a target missile, said method including the steps of:

providing a multiplicity of barrel assemblies, wherein each barrel of said assembly extends radially outwardly and each said assembly includes a plurality of projectiles axially disposed with a barrel, which projectiles are

associated with discrete propellant charges for propelling said projectiles sequentially from said barrel;

determining the path of the target missile;

selectively firing the projectiles from the circular array of barrel assemblies to form a generally homogeneous pattern of projectiles in the path of the target missile.

Suitably, said multiplicity of barrel assemblies comprises at least one circular array of barrel assemblies.

In another aspect of the invention, there is provided an interception missile for intercepting a target missile, said interception missile including:

a missile body having a longitudinal axis;

at least one planar array of barrel assemblies, wherein each barrel of said assembly extends radially outwardly from said longitudinal axis;

each said barrel assembly including a plurality of projectiles axially disposed with a barrel, which projectiles are associated with discrete propellant charges for propelling said projectiles sequentially from said barrel;

whereby projectiles may be selectively fired from the planar array of barrel assemblies to form a generally homogeneous pattern of projectiles in the path of the target missile.

Suitably, the barrels in any one planar array are arranged on coplanar radials, preferably in a circle.

Preferably, a plurality of planar arrays of barrel assemblies are provided wherein the barrels thereof extend outwardly from a common longitudinal axis thereby forming a substantially cylindrical matrix of barrel assemblies.

If required, the barrels of different planar arrays may be arranged on parallel radials. Alternatively, barrels in different planar arrays may be arranged on radials that are skewed in relation to one another. The skewed arrangement of barrels may facilitate an increase in effective deployment radius of the field of projectiles. If required, the skewed arrangement of barrels may facilitate at least partially interleaved packing of the barrels of different planar arrays.

The homogeneous pattern of projectiles is suitably formed such that, within a preselected deployment radius, the separation between individual projectiles in said pattern is less than the diameter of said enemy missile.

If required, said interception missile further includes tracking means for determining the path of the target missile.

The planar arrays of barrels are suitably fixed to the interception missile, although they may be mounted for selective rotation about the longitudinal axis of the missile as required.

In order to effect course correction, projectiles may be selectively fired from said barrels in order to deflect the missile onto a new course or trajectory.

The interception missile may further comprise a hemispherical array of barrel assemblies extending radially outwardly from a nose portion of said missile.

The present invention may take particular advantage of barrel assemblies of the type described in the earliest International Patent Applications, including No. PCT/AU94/00124 (published as WO 94/20809) and No. PCT/AU96/00459 (published as WO 97/04281) now assigned to the present applicant. Such barrel assemblies include a barrel, a multiplicity of projectiles axially disposed within the barrel for operative sealing engagement with the bore of the barrel, and discrete propellant charges for propelling respective projectiles sequentially through the muzzle of the barrel may be used in the present invention.

Barrel assemblies of this type are capable of firing a sequence of projectiles at regular intervals whereby a pre-determined distance may be established between projectiles in flight. The projectile may be round, conventionally shaped or dart-like and the fins thereof may be off-set to generate a stabilising spin as the dart is propelled from a barrel which may be a smooth-bored barrel.

The projectile charge may be form as a solid block to operatively space the projectiles in the barrel or the propellant charge may be encased in metal or other rigid case which may include an embedded primer having external contact means adapted for contacting an pre-positioned electrical contact associated with the barrel. For example the primer could be provided with a sprung contact

which may be retracted to enable insertion of the cased charge into the barrel and to spring out into a barrel aperture upon alignment with that aperture for operative contact with its mating barrel contact. If desired the outer case may be consumable or may chemically assist the propellant burn. Furthermore an assembly of stacked and bonded or separate cased charges and projectiles may be provide for reloading a barrel.

Each projectile may include a projectile head and extension means for at least partly defining a propellant space. The extension means may include a spacer assembly which extends rearwardly from the projectile head and abuts an adjacent projectile assembly.

The spacer assembly may extend through the propellant space and the projectile head whereby compressive loads are transmitted directly through abutting adjacent spacer assemblies. In such configurations, the spacer assembly may add support to the extension means that may be a thin cylindrical rear portion of the projectile head. Furthermore the extension means may form an operative sealing contact with the bore of the barrel to prevent burn leakage past the projectile head.

The spacer assembly may include a rigid collar which extends outwardly to engage a thin cylindrical rear portion of the malleable projectile head inoperative sealing contact with the bore of the barrel such that axially compressive loads are transmitted directly between spacer assemblies thereby avoiding deformation of the malleable projectile head.

Complementary wedging surfaces may be disposed on the spacer assembly and projectile head respectively whereby the projectile head is urged into engagement with the bore of the barrel in response to relative axial compression between the spacer means and the projectile head. In such arrangement the projectile head and spacer assembly may be loaded into the barrel and there after an axial displacement is caused to ensure good sealing between the projectile head and barrel. Suitably the extension means is urged into engagement with the bore of the barrel.

The projectile head may define a tapered aperture at its rearward end into which is received a complementary tapered spigot disposed on the leading end of the spacer assembly, wherein relative axial movement between the

projectile head and the complementary tapered spigot causes a radially expanding force to be applied to the projectile head.

The barrel may be non metallic and the bore of the barrel may include recesses which may fully or partly accommodate the ignition means. In this configuration the barrel houses electrical conductors which facilitate electrical communication between the control means and ignition means. This configuration may be utilised for disposable barrel assemblies which have a limited firing life and the ignition means and control wire or wires therefor can be integrally manufactured with the barrel.

A barrel assembly may alternatively include ignition apertures in the barrel and the ignition means are disposed outside the barrel and adjacent the apertures. The barrel may be surrounded by a non metallic outer barrel which may include recesses adapted to accommodate the ignition means. The outer barrel may also house electrical conductors which facilitate electrical communication between the control means and ignition means. The outer barrel may be formed as a laminated plastics barrel which may include a printed circuit laminate for the ignition means.

The barrel assembly may have adjacent projectiles that are separated from one another and maintained in spaced apart relationship by locating means separate from the projectiles, and each projectile may include an expandable sealing means for forming an operative seal with the bore of the barrel. The locating means may be the propellant charge between adjacent projectiles and the sealing means suitably includes a skirt portion on each projectile which expands outwardly when subject to an in-barrel load. The in-barrel load may be applied during installation of the projectiles or after loading such as by tamping to consolidate the column of projectiles and propellant charges or may result from the firing of an outer projectile and particularly the adjacent outer projectile.

The rear end of the projectile may include a skirt about an inwardly reducing recess such as a conical recess or a part-spherical recess or the like into which the propellant charge portion extends and about which rearward movement of the projectile will result in radial expansion of the projectile skirt. This rearward movement may occur by way of compression resulting from a

rearward wedging movement of the projectile along the leading portion of the propellant charge it may occur as a result of metal flow from the relatively massive leading part of the projectile to its less massive skirt portion.

Alternatively the projectile may be provided with a rearwardly divergent peripheral sealing flange or collar which is deflected outwardly into sealing engagement with the bore upon rearward movement of the projectile. Furthermore the sealing may be effected by inserting the projectiles into a heated barrel which shrinks onto respective sealing portions of the projectiles. The projectile may comprise a relatively hard mandrel portion located by the propellant charge and which cooperates with a deformable annular portion may be moulded about the mandrel to form a unitary projectile which relies on metal flow between the nose of the projectile and its tail for outward expansion about the mandrel portion into sealing engagement with the bore of the barrel.

The projectile assembly may include a rearwardly expanding anvil surface supporting a sealing collar thereabout and adapted to be radially expanded into sealing engagement with the barrel bore upon forward movement of the projectile through the barrel. In such a configuration it is preferred that the propellant charge have a cylindrical leading portion which abuts the flat end face of the projectile.

The projectiles may be adapted for seating and/or location within circumferential grooves or by annular ribs in the bore or in rifling grooves in the bore and may include a metal jacket encasing at least the outer end portion of the projectile. The projectile may be provided with contractible peripheral locating rings which extend outwardly into annular grooves in the barrel and which retract into the projectile upon firing to permit its free passage through the barrel.

The electrical ignition for sequentially igniting the propellant charges of a barrel assembly may preferably include the steps of igniting the leading propellant charge by sending an ignition signal through the stacked projectiles, and causing ignition of the leading propellant charge to arm the next propellant charge for actuation by the next ignition signal. Suitably all propellant charges inwardly from the end of a loaded barrel are disarmed by the insertion of

respective insulating ruses disposed between normally closed electrical contacts.

Ignition of the propellant may be achieved electrically or ignition may utilise conventional firing pin type methods such as by using a centre-fire primer igniting the outermost projectile and controlled consequent ignition causing sequential ignition of the propellant charge of subsequent rounds. This may be achieved by controlled rearward leakage of combustion gases or controlled burning of fuse columns extending through the projectiles.

In another form the ignition is electronically controlled with respective propellant charges being associated with primers which are triggered by distinctive ignition signals. For example the primers in the stacked propellant charges may be sequenced for increasing pulse width ignition requirements whereby electronic controls may selectively send ignition pulses of increasing pulse widths to ignite the propellant charges sequentially in a selected time order. Preferably however the propellant charges are ignited by a set pulse width signal and burning of the leading propellant charge arms the next propellant charge for actuation by the next emitted pulse.

Suitably in such embodiments all propellant charges inwardly from the end of a loaded barrel are disarmed by the insertion of respective insulating fuses disposed between insertion of respective insulating fuses disposed between normally closed electrical contacts, the fuses being set to burn to enable the contacts to close upon transmission of a suitable triggering signal and each insulating fuse being open to a respective leading propellant charge for ignition thereby.

A number of projectiles can be fired simultaneously, or in quick succession, or in response to repetitive manual actuation of a trigger, for example. In such arrangements the electrical signal may be carried externally of the barrel or it may be carried through the superimposed projectiles which may clip on to one another to continue the electrical circuit through the barrel, or abut in electrical contact with one another. The projectiles may carry the control circuit or they may form a circuit with the barrel.

Brief Details of the Drawings

In order that this invention may be more readily understood and put into practical effect, reference will now be made to the accompanying drawings illustrate preferred embodiments of the invention, and wherein:

FIG. 1 depicts a prior art fragmentation pattern;

FIG. 2 depicts an end view of a circular array of barrel assemblies in accordance with a first embodiment of the invention;

FIG. 3 depicts a sequence of projectiles fired from one of the barrel assemblies of FIG. 2;

FIG. 4 depicts the sequence of projectiles of FIG. 3 relative to notional enemy missile positions;

FIG. 5 is an end view of the array of barrel assemblies of FIG. 2 depicting firing lines of projectiles from each barrel;

FIG. 6 is an end view of the array of barrel assemblies of FIG. 2 depicting reactionary forces of firing;

FIG. 7 is an end view of the array of barrel assemblies of FIG. 2 depicting deployment of projectiles in relation to an effective radius;

FIGs 8 to 10 are end views of a variety of possible paths of enemy missiles relative to the array of barrel assemblies;

FIGs 11 and 12 are each end views of possible paths of enemy missiles relative to the projectile deployment radius;

FIG 13 depicts how stacked arrays of barrel assemblies form a cylindrical matrix of barrels of a second embodiment;

FIG. 14 illustrates the trigonometrical relationship between deployment radius and lines of fire of projectiles;

FIGs. 15a and 15b illustrate an alternative offset stacking of barrel arrays to form a further matrix of barrels;

FIG. 16 illustrates the lines of fire of projectiles from the matrix of barrels of FIG. 15;

FIG. 17 is a scaled representation of the relationship between deployment radii and stacked barrel arrays in a cylindrical matrix;

FIG. 18 is a side view of a projectile field deployed by an interception missile carrying a matrix of barrels;

FIGs. 19a and 19b provide a comparison between projectile fields deployed by a different embodiments of the invention;

FIG. 20 is a scaled representation of the lines of fire of a field of projectiles deployed from a matrix of barrel assemblies;

FIG. 21 is a cross-sectional view of a first embodiment of an interception missile including an array of barrel assemblies;

FIG. 22 is a side elevational view of an interception missile showing deployment radius;

FIG. 23 is an end view comparing the effective radius of a prior art hit-to-kill interception missile with an embodiment of an interception missile of the present invention;

FIG. 24 is a side view of the interception missile of FIG. 21;

FIGs 25a, 25b and 25c illustrate the effective 'width' of the deployed field of projectiles for different angles between the trajectories of the two missiles of FIG 23;

Description of the Preferred Embodiments

With reference to Figure 2, there is shown an end view of a multiplicity of barrel assemblies in the form of a circular array of barrel assemblies 14 of the type described. The barrels comprising the array 16 are coplanar, regularly spaced and extend outwardly from the centre of the circle. The barrel assemblies each include axially stacked projectiles associated with respective propellant charges. The projectiles may have reduced propellant loads moving sequentially towards the rear of the barrel, in order to maintain a constant muzzle velocity.

Figure 3 shows a line of projectiles 18 being fired from one of the barrels (not shown) of the circular array 14. The distance X between projectiles 18 fired from the barrel may be determined solely by the amount of time between each firing. For example, a single barrel of this type can currently fire at up to 45,000 rounds per minute (RPM), currently with a consistent separation between projectiles of less than 380mm (15 inches).

Accordingly, if this separating distance X is set to be slightly less than the cross-sectional diameter of an enemy missile 10, the missile has an excellent chance of being hit (at least once) if it is to cross the line of fire 20 of the projectiles 18, as shown in Figure 4. In all diagrams of this type presented herein, the enemy missiles 10 are travelling through the page and generally perpendicular to the lines of fire 20 of the barrel array 14.

In the event that all of the barrels 16 of the array of barrel assemblies are fired simultaneously, Figure 5 depicts the lines of fire 20 of each barrel in the array 14. It is desirable that projectiles are fired from opposing barrels at the same time, as depicted in Figure 6, so that there is zero net recoil. This avoids any unintended change to the course of a kill vehicle, such as an interception missile, carrying the array of barrel assemblies 14.

Thus, with reference to Figure 7, the array of barrel assemblies 14 is designed such that, not only is the distance X between each projectile 18 in a line of fire less than the cross-sectional diameter of an enemy missile, but so is the distance Y between each line of projectiles from adjacent barrels smaller than said diameter at all points along the respective lines of fire 20. It will be appreciated that the distance between each line of projectiles varies with the radial distance from the muzzle of the barrels, in that the first fired or lead projectiles have the greatest separation from one another. Accordingly, the distance between the lead projectiles is set to be less than the cross-sectional diameter of the target enemy missile when the lead projectiles are at the deployment radius R. The deployment radius R may be defined as the radial distance of the lead projectile is from the muzzle when (i) all projectiles 18 have been fired from respective barrels of the array 14, and (ii) the distance between the array 14 and the last projectile fired is slightly less than said cross-sectional diameter of the enemy missile, ie. X in Figure 7. It should be noted in considering Figure 7 (and similar drawings) showing only three lines of fire of projectiles, that projectiles 18 are desirably fired in opposed directions from the array of barrel assemblies 14, and most desirably from all barrels simultaneously (see Figures 11 and 12).

From the above description, it can be seen that where an enemy missile 10 passes through a field of deployed projectiles 18, the missile is virtually

certain of being hit at least once. A single hit is however relatively unlikely, since the missile 10 must exactly pick the 'gap' amongst surrounding projectiles as depicted in Figure 8. A much more likely scenario is that the enemy missile will be hit between two (2) and four (4) times for each array of barrel assemblies 14, as depicted in Figures 9 and 10, respectively. It is notable that, unlike the prior art, the hits are not merely fragmentary interceptions, but impacts by projectiles generally having higher mass than fragments.

Figure 11 is a scaled representation of the area covered by an array of barrel assemblies having a 0.5m diameter operating with a deployment radius R of 5m. Whilst the earlier diagrams show an enemy missile, such as an ICBM, passing through the field near the outer edge of the deployment radius, Figure 12 shows the effect when the enemy missile passes closer to the array of barrel assemblies 14. Clearly the missile will suffer a significantly higher number of impacts, such as in the order of seven (7) to fourteen (14).

It is also observed that the high speed of the ICBM in relation to the projectiles means that the deployed projectile field virtually 'waits' for the enemy missile 10 to pass through the entire area or volume of the field. (A three dimensional field of projectiles will be described below). For example, the projectiles will move less than 5cm for every meter that the ICBM moves. This is simply factored into the firing system timing to deploy the projectile field.

A multiplicity of barrels 22 of a second embodiment of the invention will now be described in relation to Figure 13. A more effective missile defence system can be provided by stacking a plurality of circular arrays of barrel assemblies 14 along a common longitudinal axis 24 to form a generally cylindrical matrix 22 of barrel assemblies. Note that, for purposes of clarity, only the topmost array 14 of barrel assemblies is depicted in the drawing. In one proposal, fifty (50) circular arrays of barrel assemblies could be stacked together in a cylindrical matrix approximately 750mm in length. In one form of the second embodiment, the individual barrels of each array could be arranged to be aligned, one with the next.

A simple mathematical relationship is depicted in Figure 14 relating to any two straight lines drawn from a point, wherein: If at a distance of z along line 1, the two lines are separated by a distance y, then at a distance of 2z

along line 1, the lines will be separated by a distance of 2y, and so on. In a second form of this embodiment, every alternative array of barrels 32, 34 of the matrix could be rotated or skewed such that individual barrels 36, 38 of respective arrays are offset from one another. This is represented by the side view of the matrix 30 illustrated in Figure 15a and the partial end view (not to the same scale) shown in Figure 15b.

This means that the projectile separation characteristics of the matrix of barrels 30 could be maintained to twice the deployment radius 2R of the matrix 22 of the first form. However, when the lead projectiles reach twice deployment radius, the last projectiles will have traveled to a single deployment radius R, as depicted in Figure 16. Accordingly, a third array of barrel assemblies will be required to provide a field of projectiles in the area within a single deployment radius R. The first projectiles of the third array are desirably timed to be fired in sequence after that last projectiles of the first and second arrays are fired.

Figure 17 is a scaled representation of the radial extent of three dimensional projectile fields that could be deployed from a cylindrical matrix of barrel assemblies, employing multiple skewed circular arrays of barrels. Distances of up to 12 deployment radii (12R) are shown. The number of circular arrays that would be required in order to deploy to each radius multiple is shown as a tabular list on the left of the drawing. The list shows that a cylindrical matrix having fifty (50) planar arrays of barrel assemblies could deploy a field of projectiles to a distance of 9R, or approximately 45m in the notional example. Further issues to be borne in mind are that the deployed field of projectiles 40 is effectively only one "plane" deep and only truly planar to a target (not shown) traveling along a path substantially perpendicular to the trajectory of a kill vehicle or interception missile 42 carrying the cylindrical matrix of barrels, as depicted in Figure 18.

In a third form of the second embodiment, the matrix of barrel assemblies could be arranged to deploy projectiles out to a maximum effective radius of 5R, or 25m in the example. The list in Figure 17 indicates that this would provide an excess of thirty-four (34) planar arrays of barrel assemblies for further carpet the effective radius. This in turn would greatly increase the probable number of projectile interceptions with the effective radius. The deployment of projectiles

from different planar barrel arrays may also be skewed in time, meaning that the number of deployed planar arrays is not only the divisor as to the distance between adjacent lines of fire (as above), but also as to the distance between projectiles in a line of fire (in end view). Accordingly, this option is considered to be advantageous in the event that an enemy missile deploys decoy warheads and other fragments.

Figure 20 illustrates the lines of fire 44 where a matrix of eight skewed barrel assemblies 46 are caused to deploy projectiles in a ring shaped field, which field is arranged to persist up to a distance of nine deployment radii (9R). It is anticipated that local tracking of the trajectory of the enemy missile may be required in order to provide sufficiently flexible fire control, whereby the timing of firing could be adapted to the particular circumstances encountered by the interception missile.

We now turn to consider the adaptation of the multiplicity of barrel assemblies of the invention to interception missiles. Whilst further embodiments of the invention are described in relation to such missiles, it will be appreciated that similar considerations may apply to adaptations of planar barrel assemblies to kill vehicles deployed from an interception missile. The embodiments are particularly concerned with interception of target missiles which takes place in the latter mid-course or terminal phase of the target missile's trajectory. Accordingly, it is expected that the angle between the trajectory of the target missile and the interception missile would be relatively small.

Figure 21 shows a cross-sectional view of an interception missile 50 of a first embodiment. Referring also to Figure 24, the missile 50 is fitted with a cylindrical matrix of barrel assemblies 52 in a neck portion 54 of the missile, rearwardly of the missile's nose 56 and below the outer skin 58 of the missile body. In one proposal the interception missile 50 having a 6m length L could be fitted with a barrel matrix comprising up to fifty (50) planar arrays of barrel assemblies in a 750mm long section of the neck 54, wherein the planar arrays could be each 15mm thick.

A field of projectiles 60 is deployed from the matrix of barrel assemblies 52 in the manner described above, at the moment before intercepting the enemy missile 10, as depicted in Figure 22. Figure 23 illustrates a scale representation of the difference between the radius of a regular hit-to-kill interception missile 10 and the deployment radius 60 of the interdiction missile 50 of the present embodiment.

The illustrations in FIGs 25a to 25c illustrate that the optimum angle of approach is 0-degrees (or 180-degrees relative to one another) because the effective width of the projectile field is maximised, as shown in Figure 25a. An approach angle of 90-degrees the advantages of the missile system are largely lost. At acute angles of approach, as depicted in Figure 25c, the extent of coverage of the projectile field 60 is geometrically reduced to the effective field 62.

In order to mitigate the undesirable effects of a less than optimum angle of approach, projectiles may be selectively fired from one side or quadrant of the missile as required - thereby functioning as a divert propulsion system to effect changes to the trajectory of the interception missile 50, as depicted in Figure 26. Further barrel assemblies could be included in the tail portion of the missile in order to add vector momentums to the missile as desired.

In a second embodiment of the interception missile of the invention, we turn to consider engagement of enemy missiles in the early mid-course segment of trajectory, wherein the approach angle may be nearer to 90-degrees. In the interception missile 70 illustrated in Figure 27, there is provided a multiplicity of barrel assemblies 72, extending generally radially outwardly and arranged in a substantially hemispherical configuration on the nose portion of the missile 70. This weapon sub-system might be conveniently conceptualised as a hemispherical array of barrel assemblies with barrels extending from a common point, in contradistinction to the cylindrical matrix described above wherein barrels extend from a common longitudinal axis. A nose cone would desirably be provided over the subsystem 72 during flight, and ejected shortly prior to engagement.

In a further form of the invention, a missile 80 may include both a hemispherical array of barrel assemblies 82 on a nose portion and a cylindrical matrix of barrel assemblies 84 on a collar portion of the missile 80, for maximum flexibility in enemy missile engagement.

Turning to Figure 29, the hemispherical array of barrel assemblies carried by missile 70 would deploy a somewhat frustro-concial field of projectiles 74. Since the projectiles are fired forwardly of the missile 70, there would be a resultant rearward force which would tend to slow the missile. However, this may be used to advantage in that the slowing due to projectile deployment could assist in providing a longer time window for a subsequent hit-to-kill intercept by the body of the missile 70.

It is to be understood that the above embodiments have been provided only by way of exemplification of this invention, and that further modifications and improvements thereto, as would be apparent to persons skilled in the relevant art, are deemed to fall within the broad scope and ambit of the present invention described herein.

Dated this SIXTEENTH day of AUGUST 2002
METAL STORM LIMITED
by
PIZZEYS Patent and Trade Mark Attorneys

Figure 1

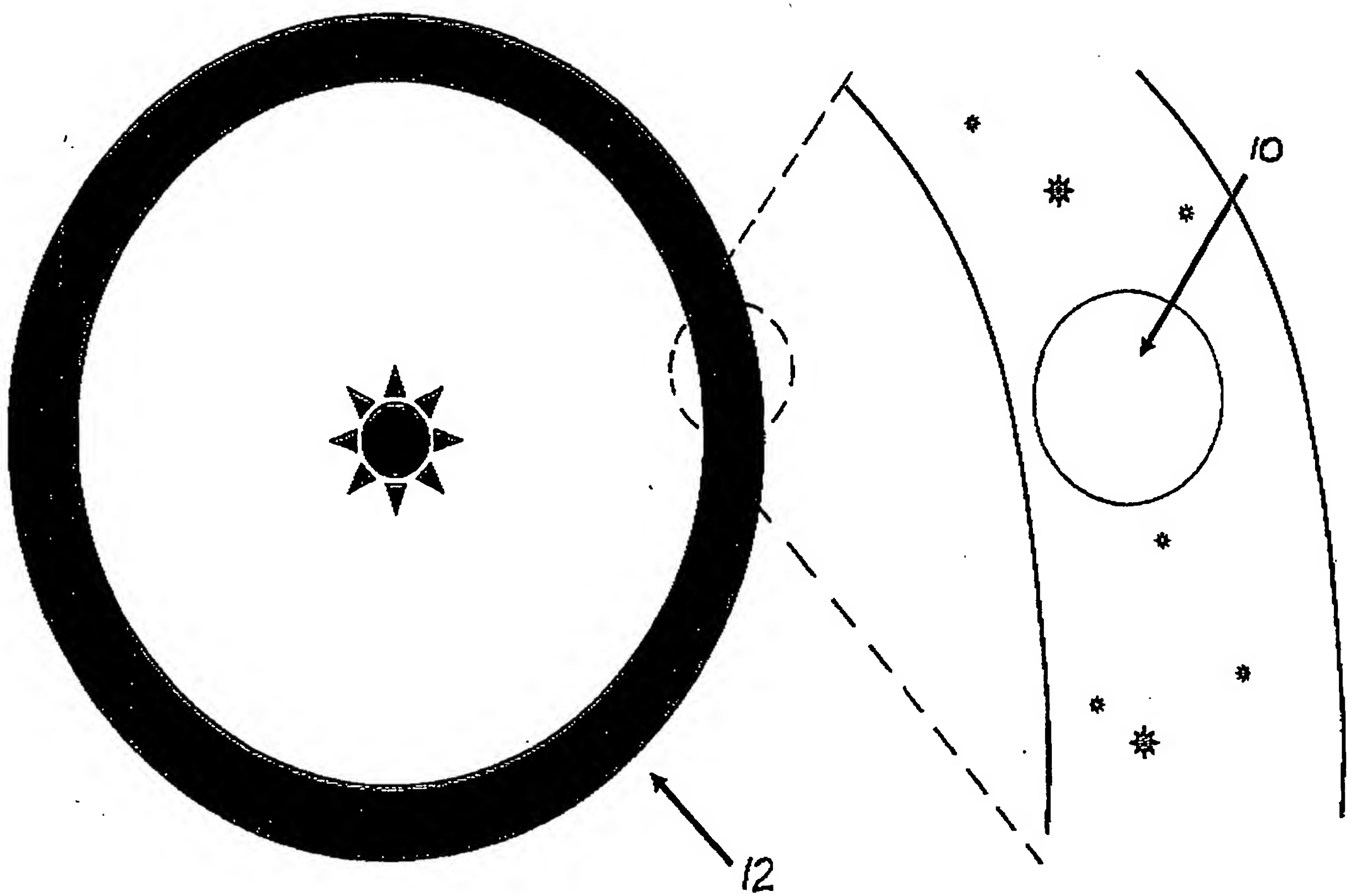


Figure 2

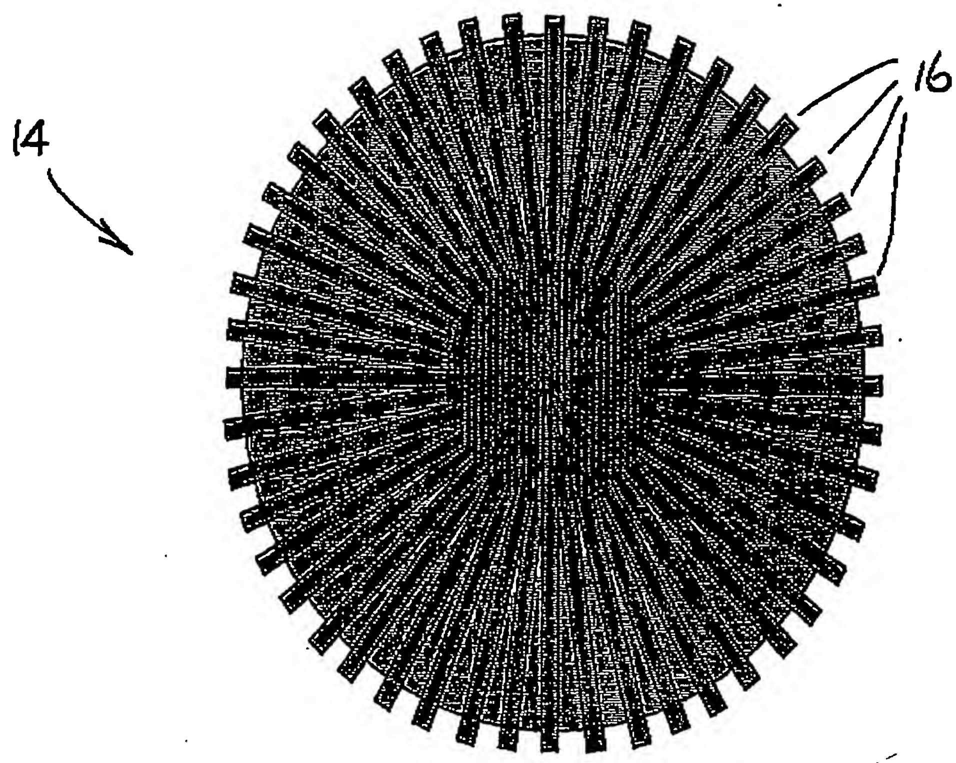


Figure 3

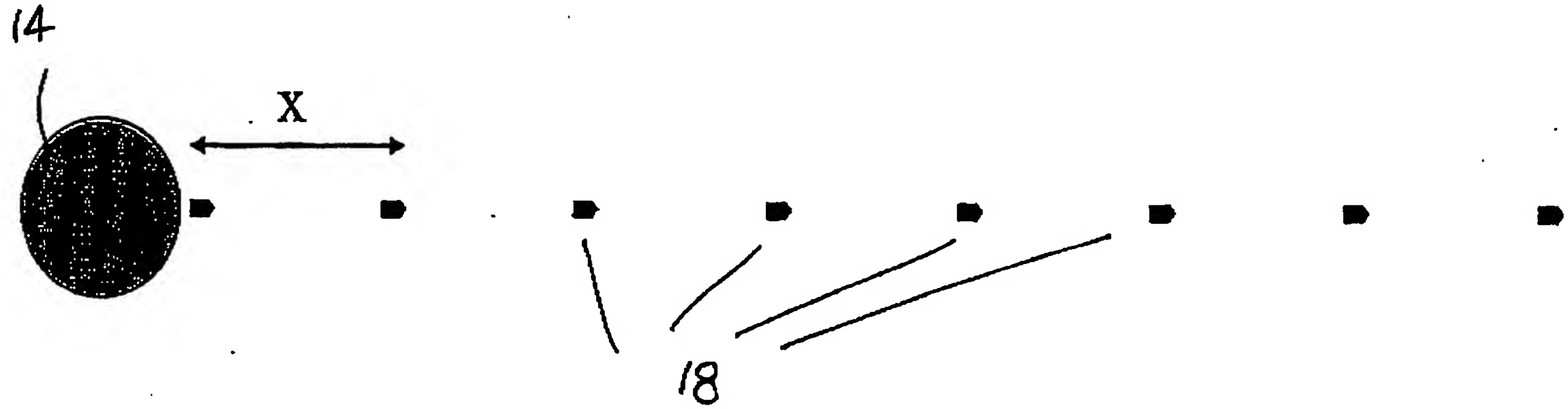


Figure 4

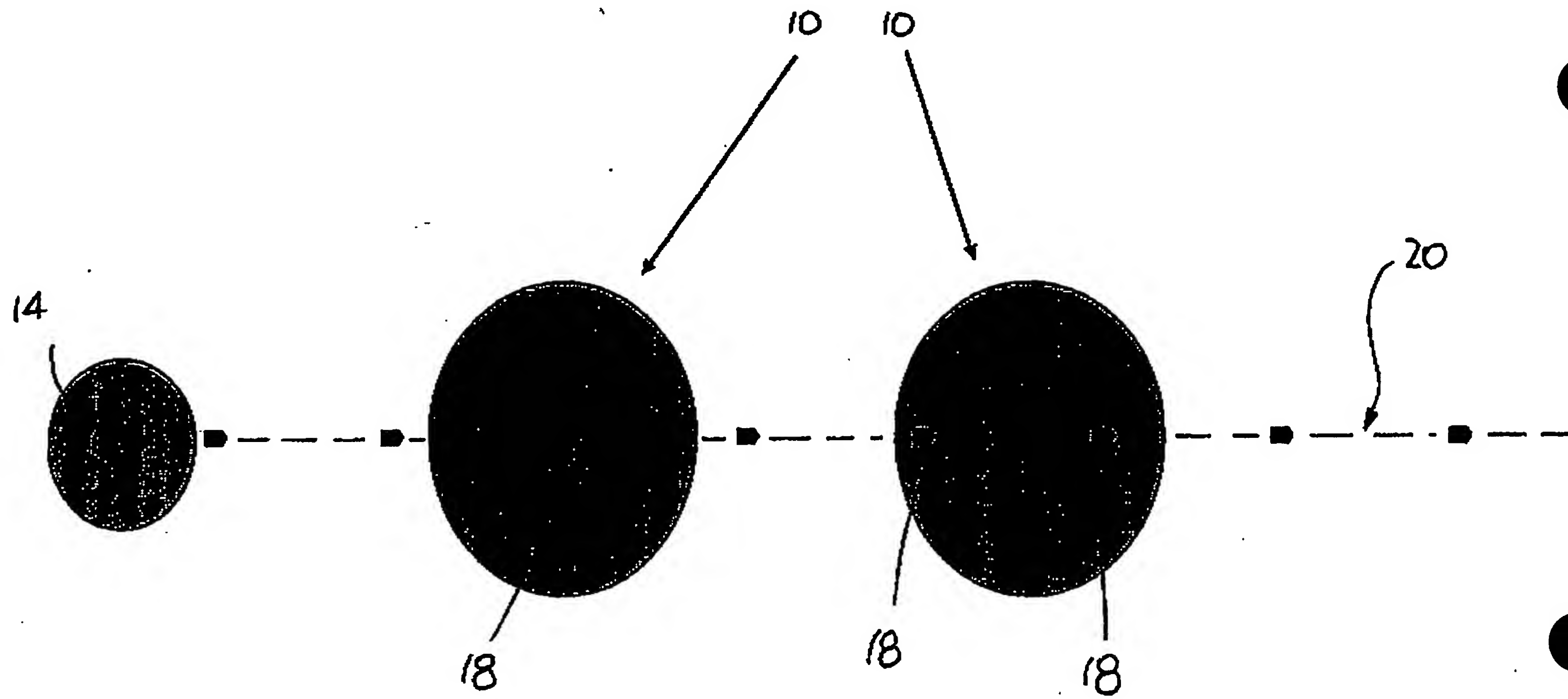


Figure 5

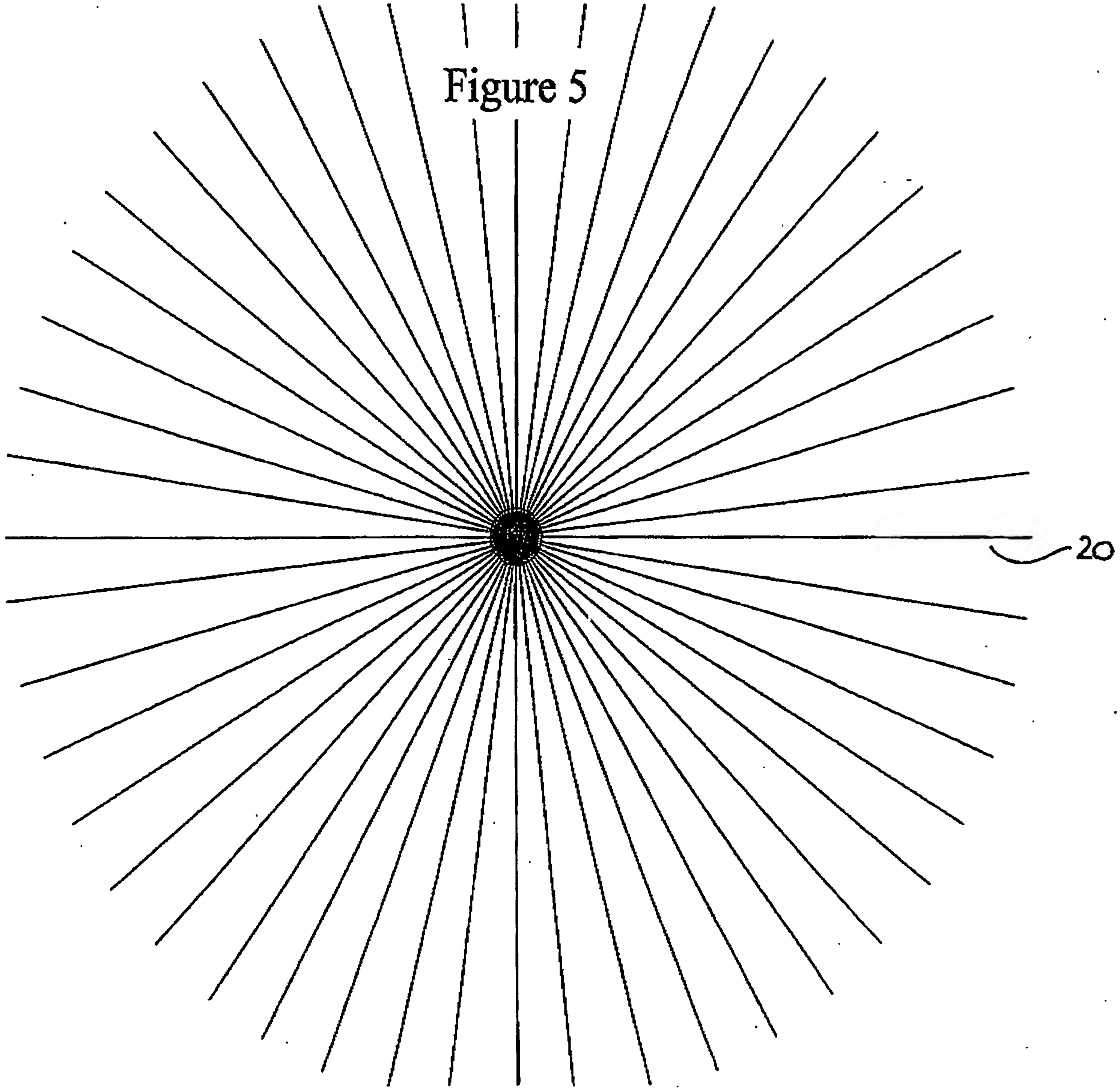


Figure 6

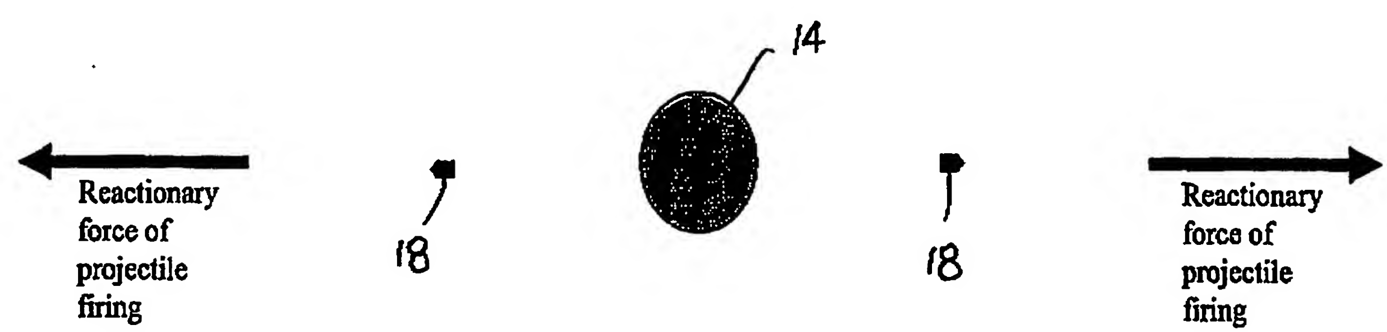

Reactionary force of projectile firing
18
14
18
Reactionary force of projectile firing

Figure 7

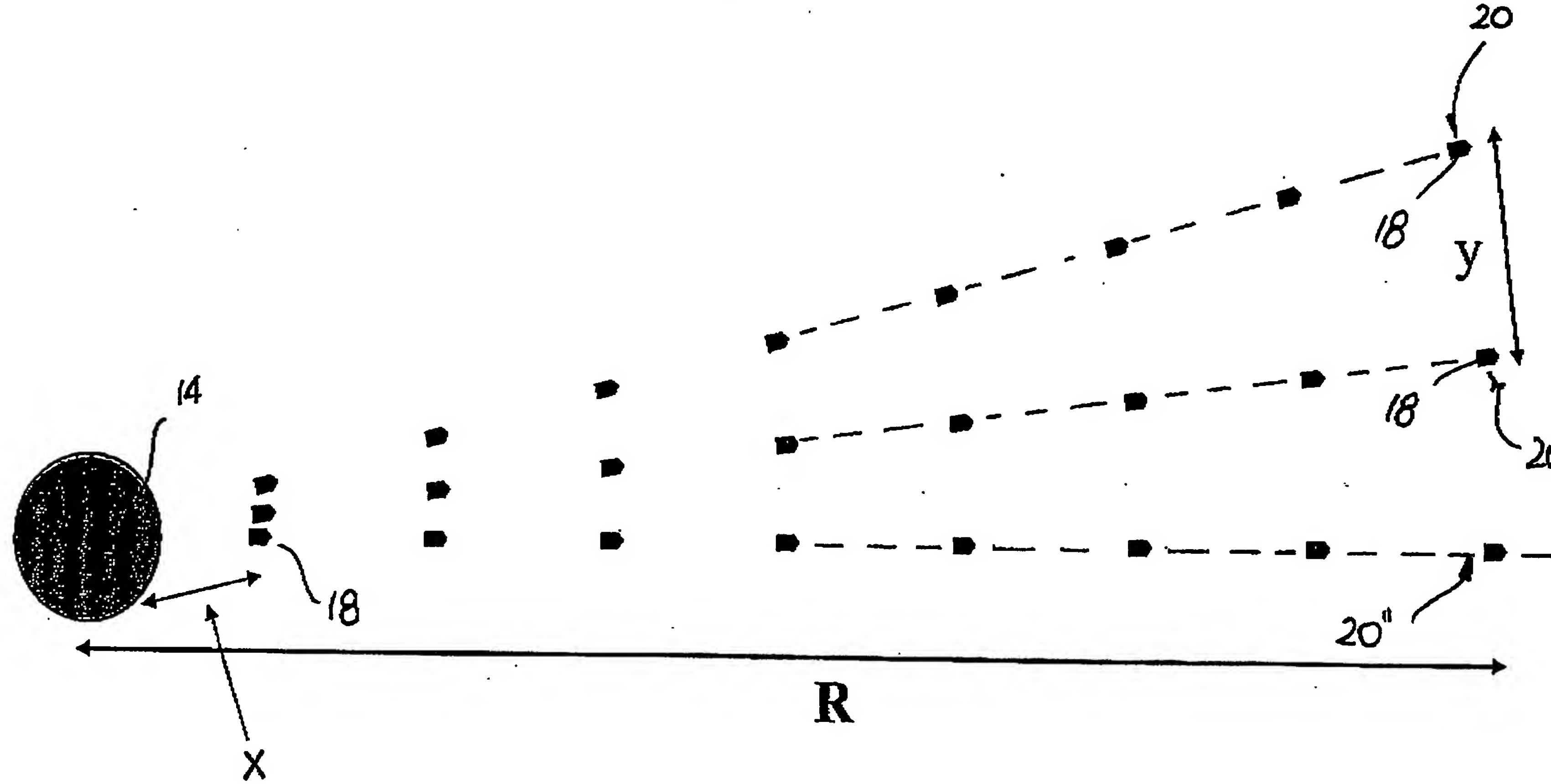


Figure 8

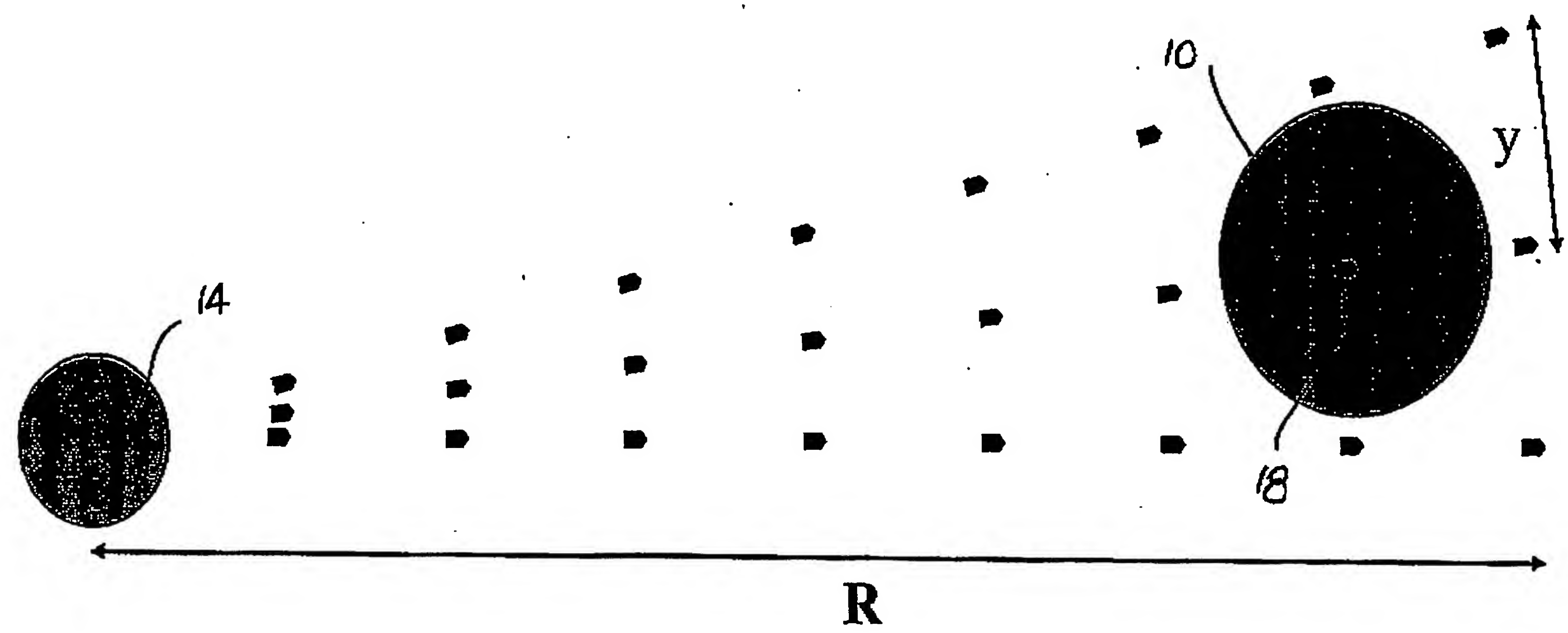


Figure 9

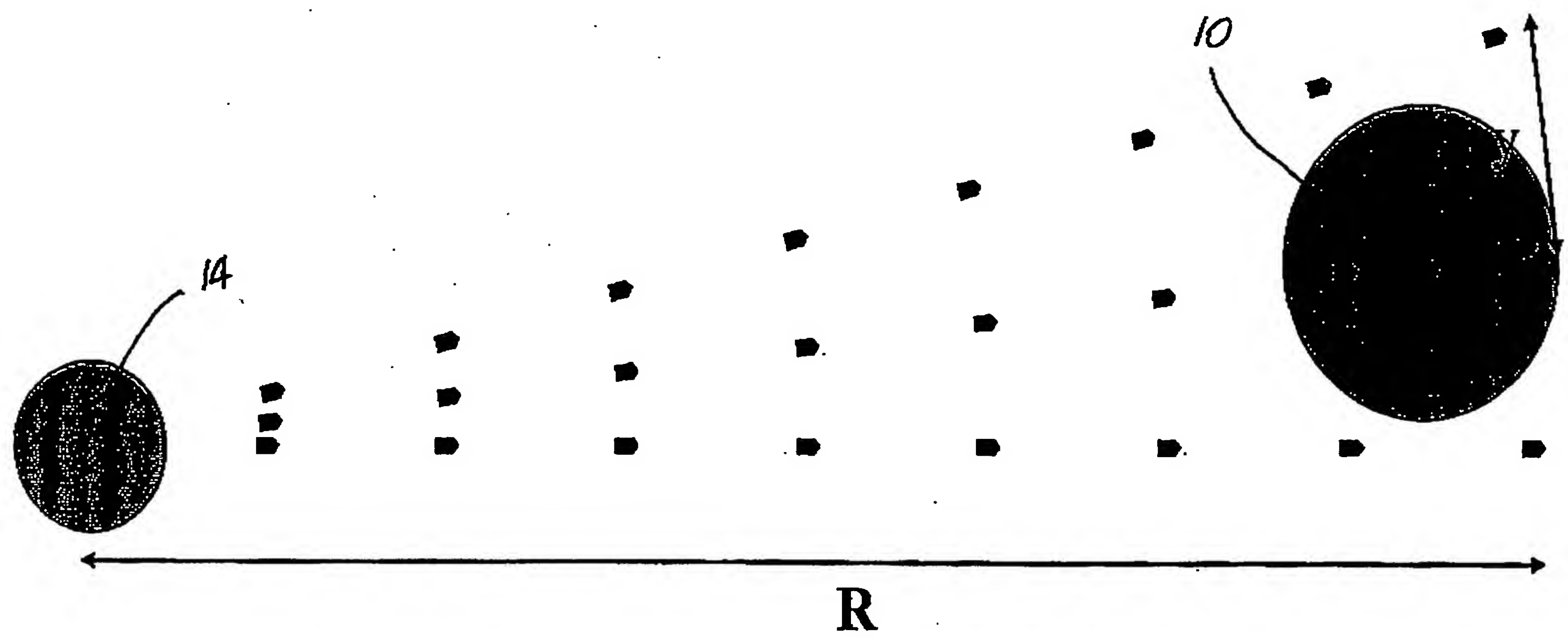


Figure 10

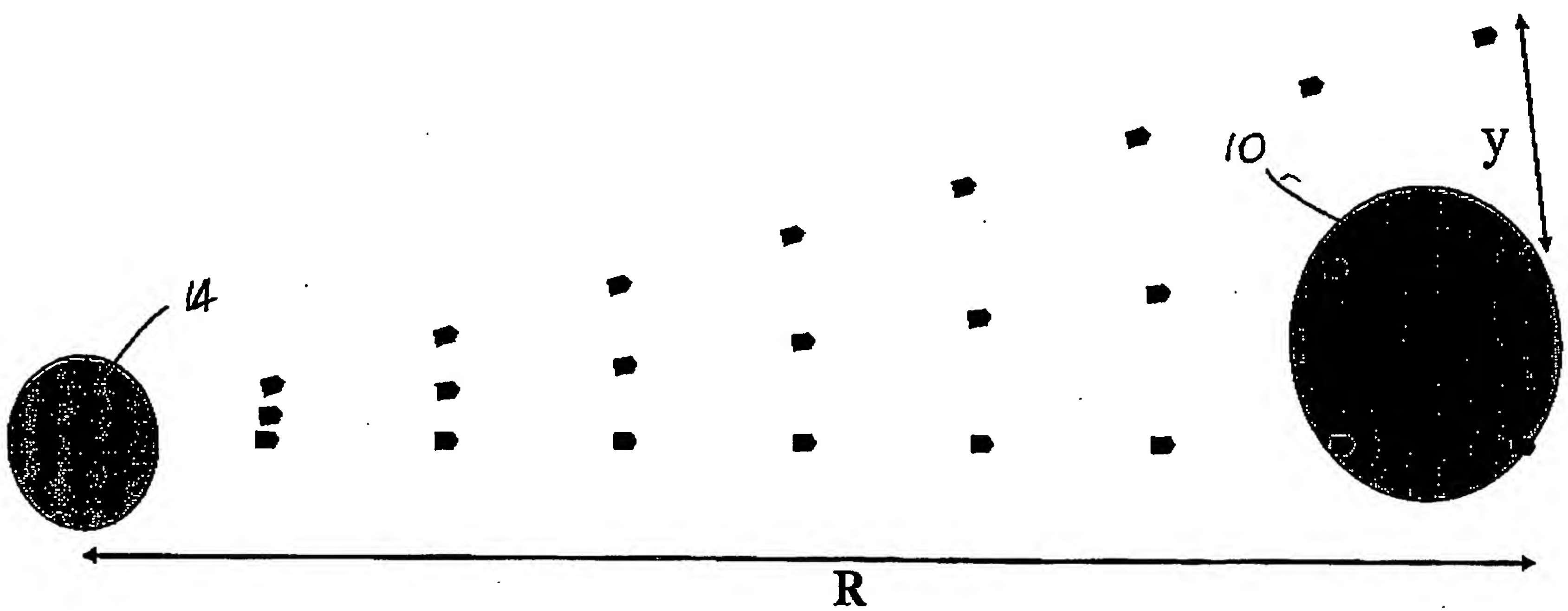


Figure 11

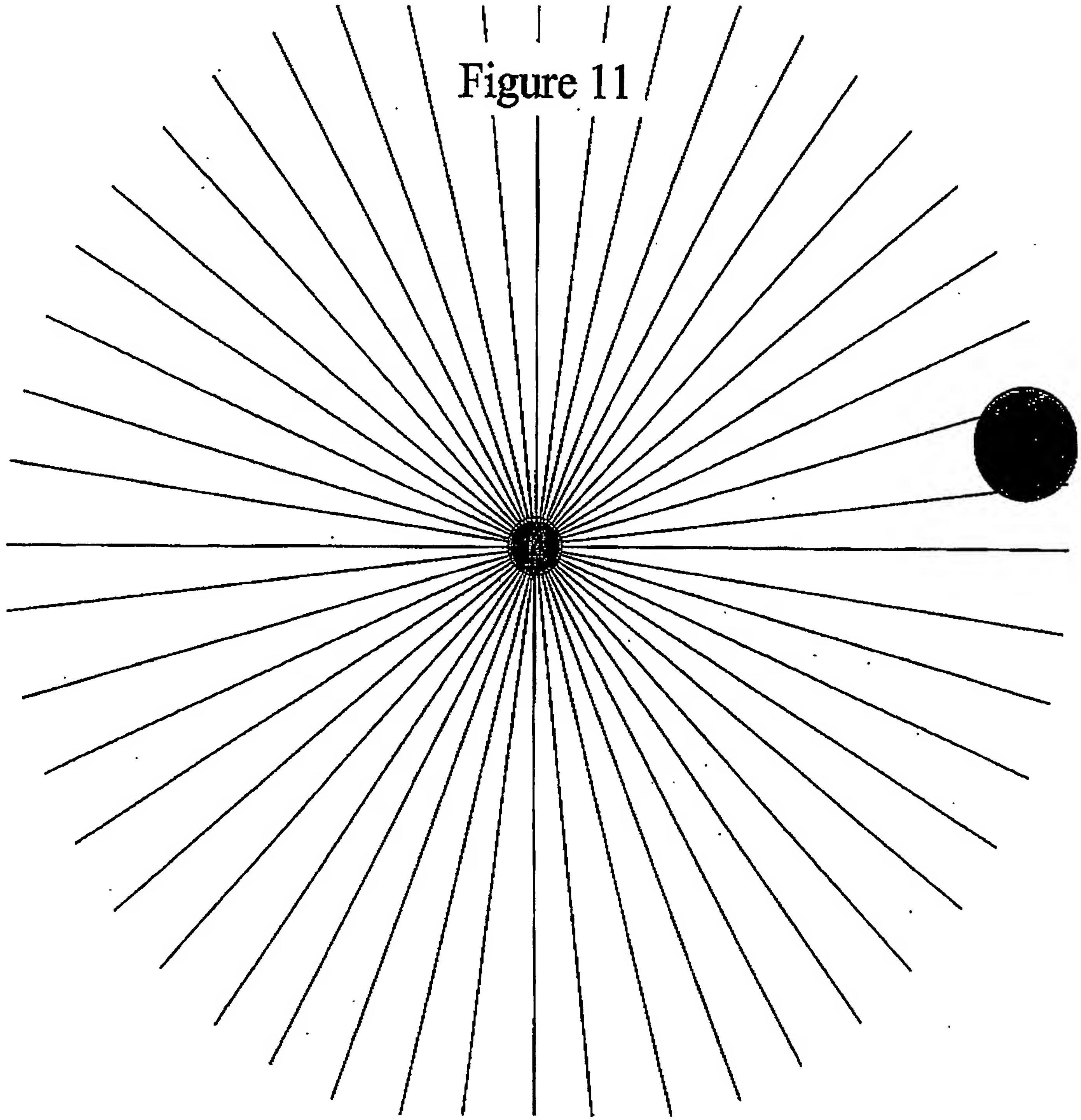


Figure 12

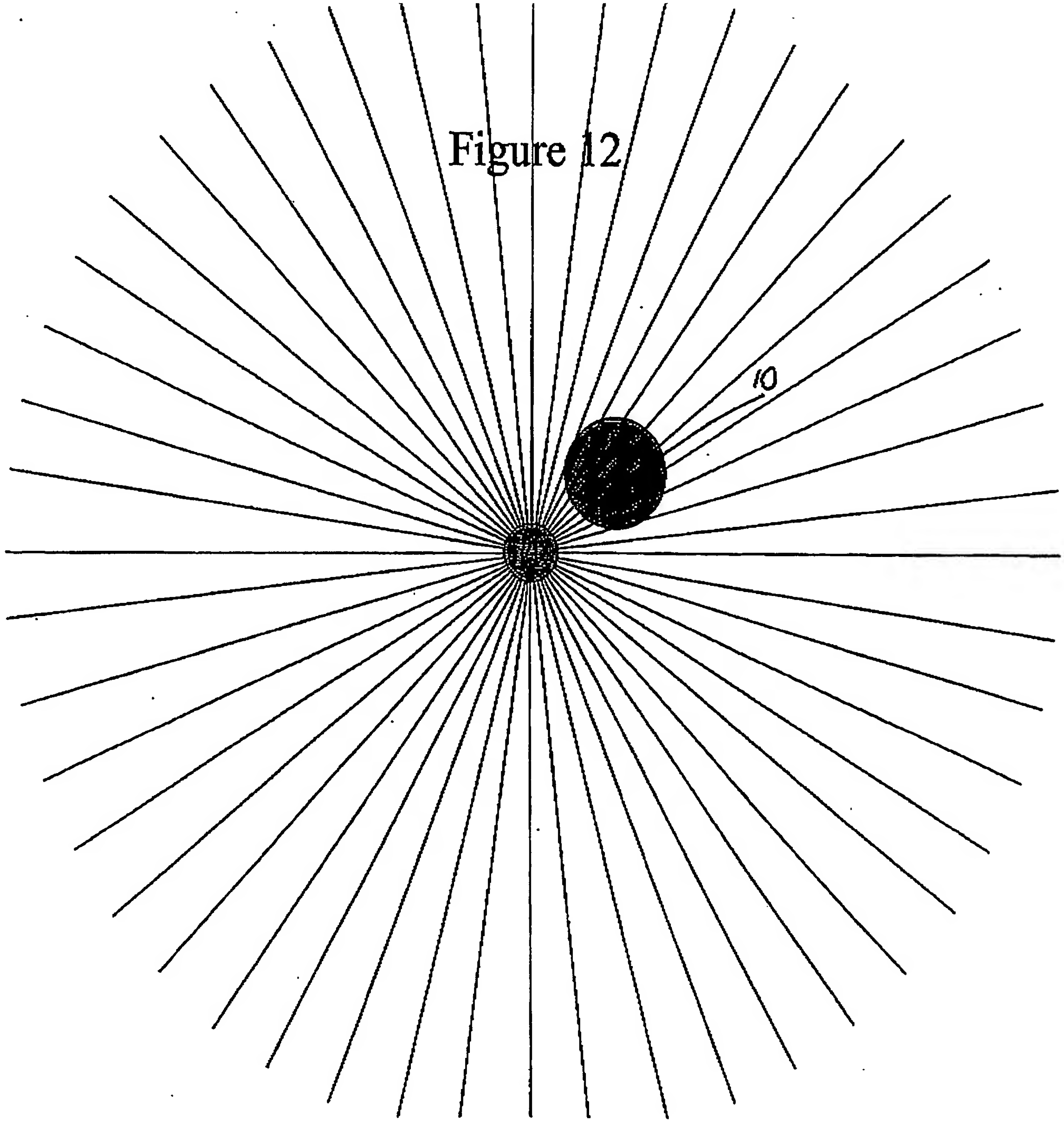


Figure 13

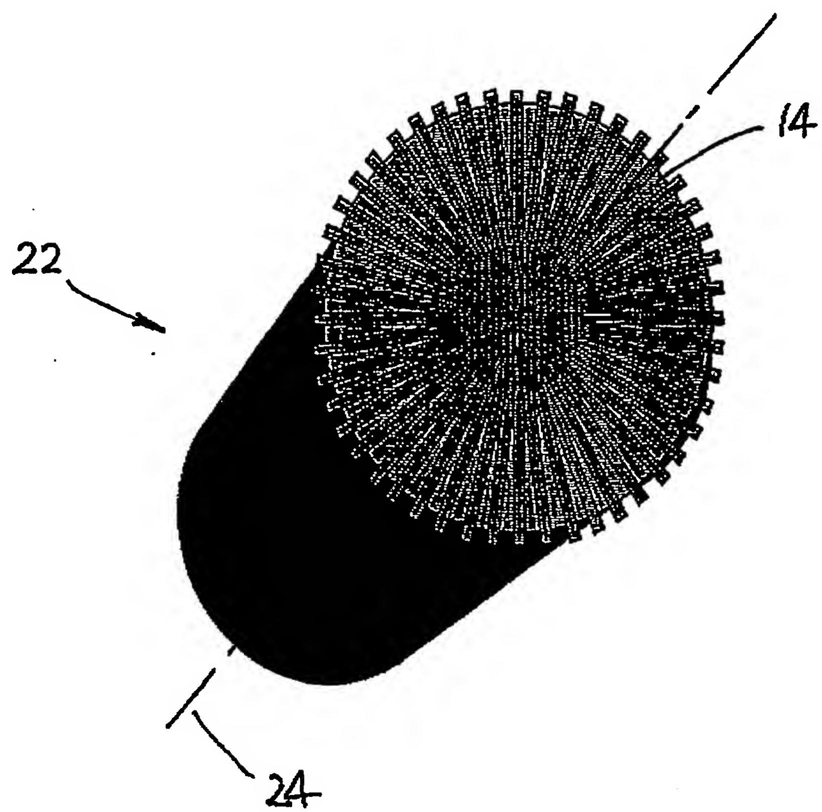


Figure 14

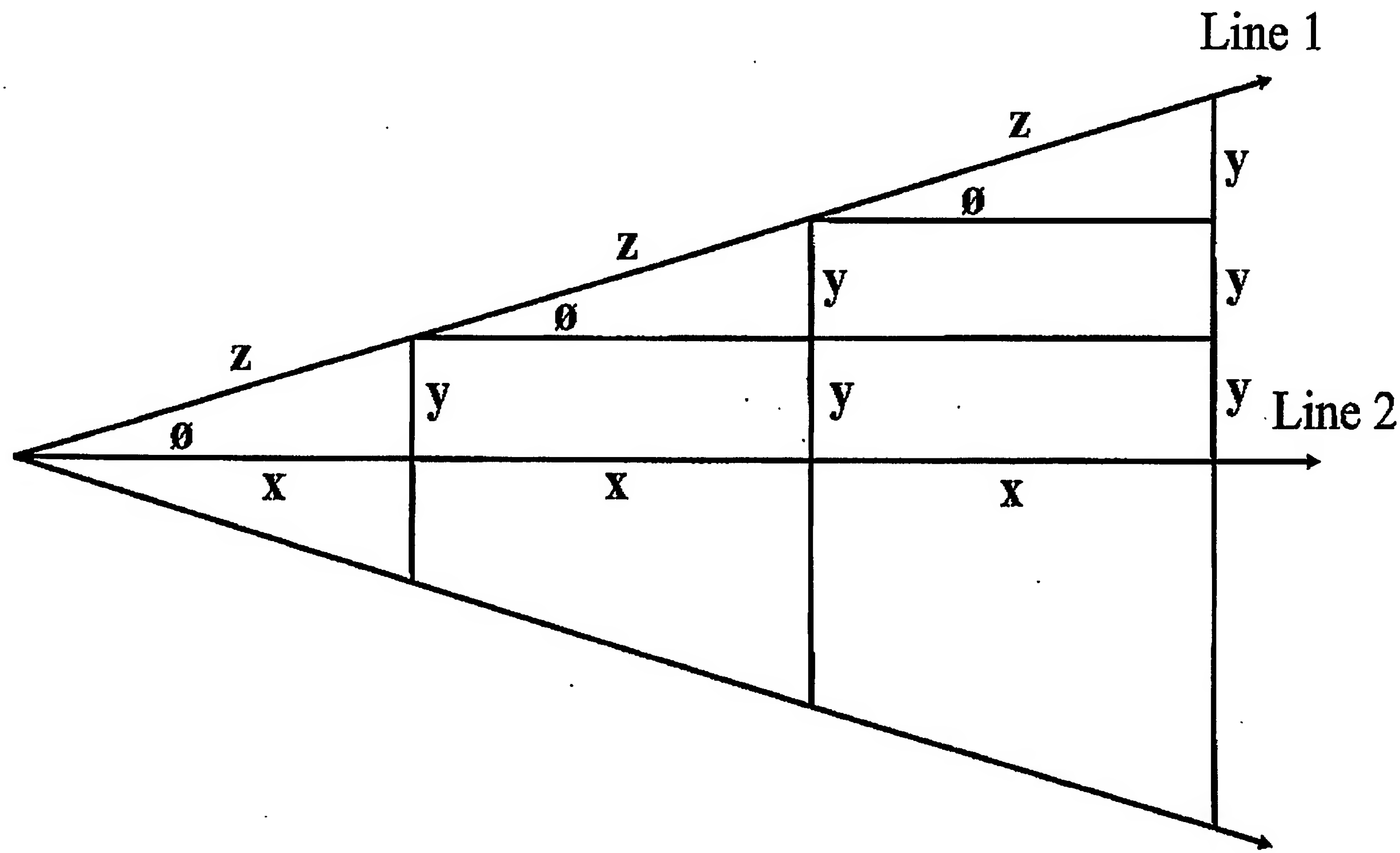
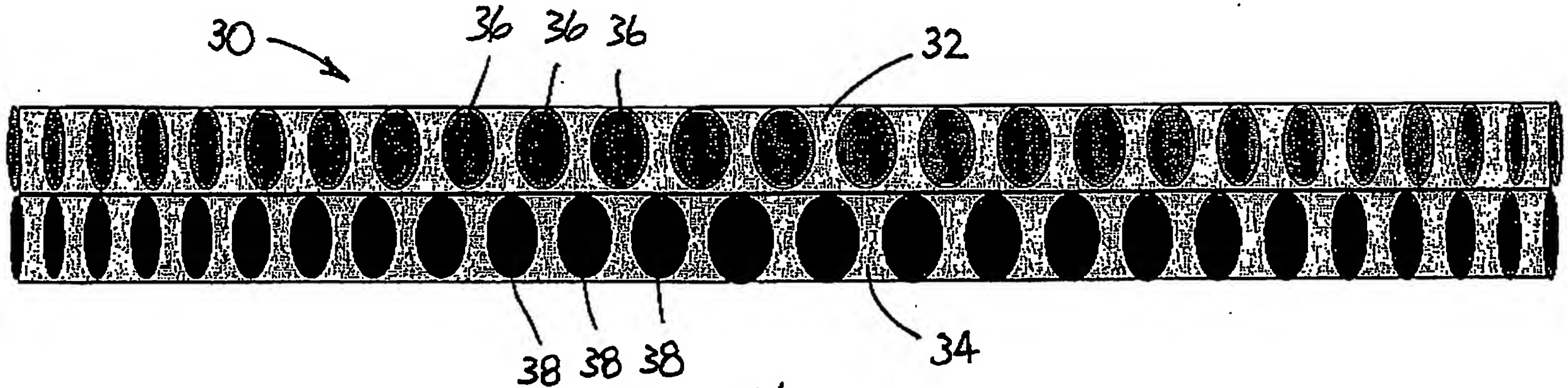


Figure 15a



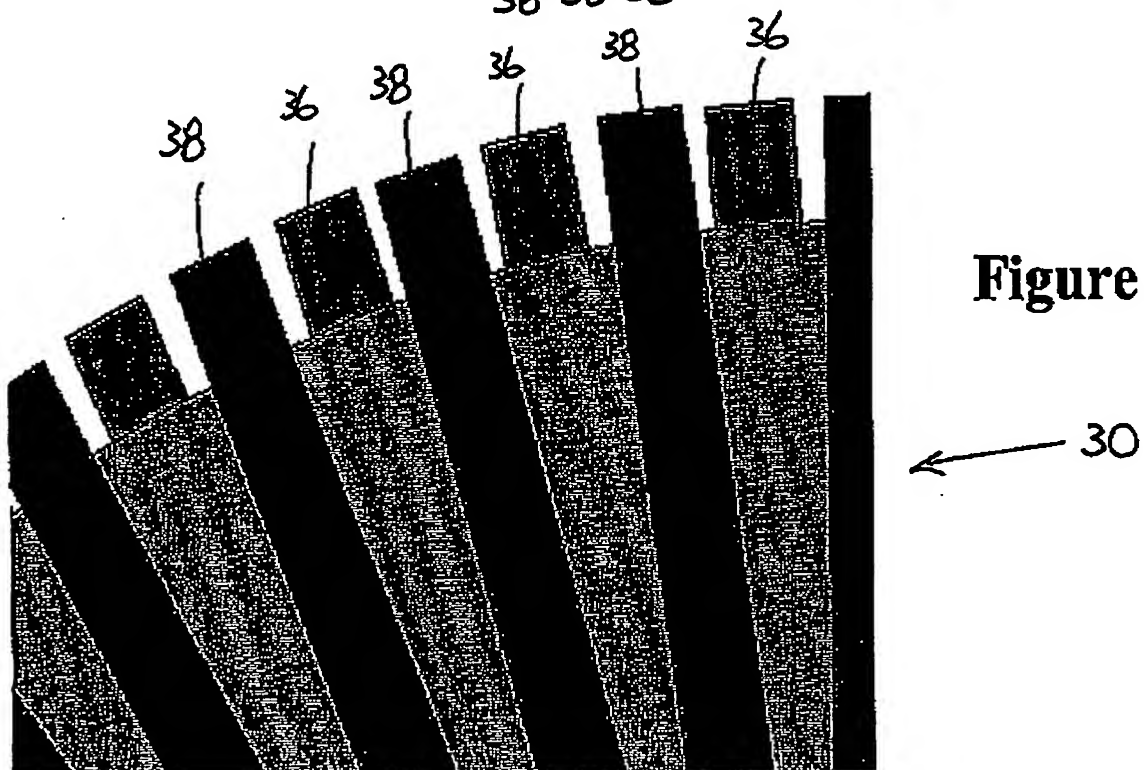


Figure 15b

Figure 17

Area covered in deployment radii (R)	No. of planar barrel arrays
1	1
2	3
3	7
4	11
5	16
6	22
7	29
8	37
9	46
10	56
11	67
12	79

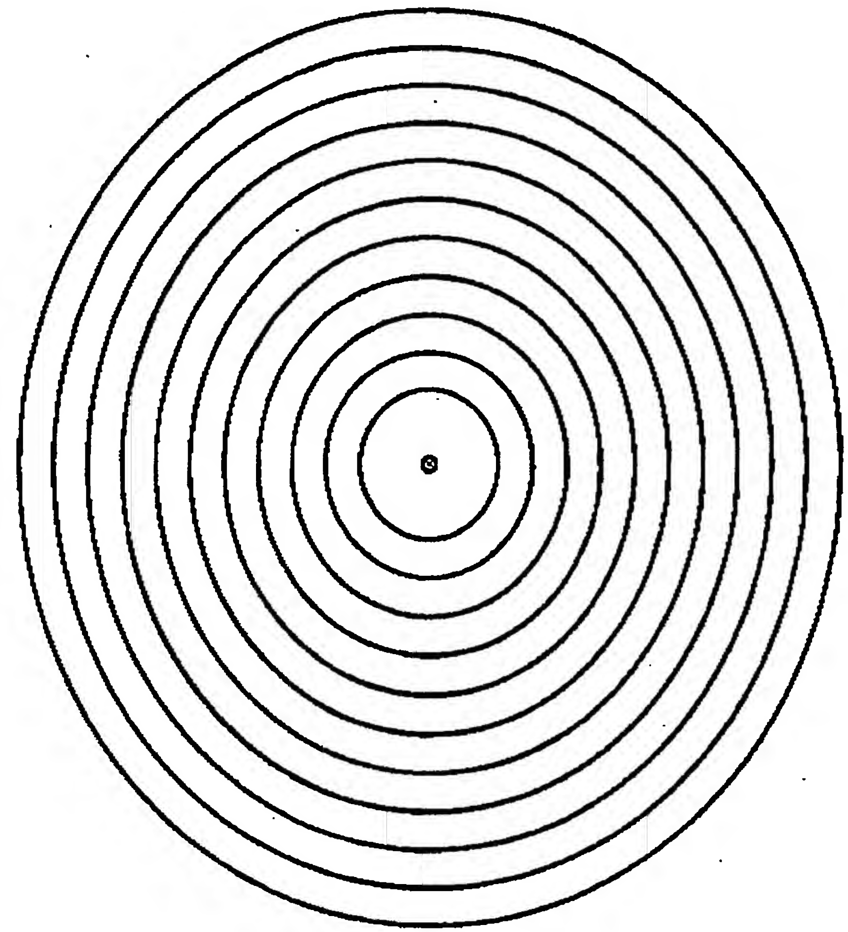


Figure 18

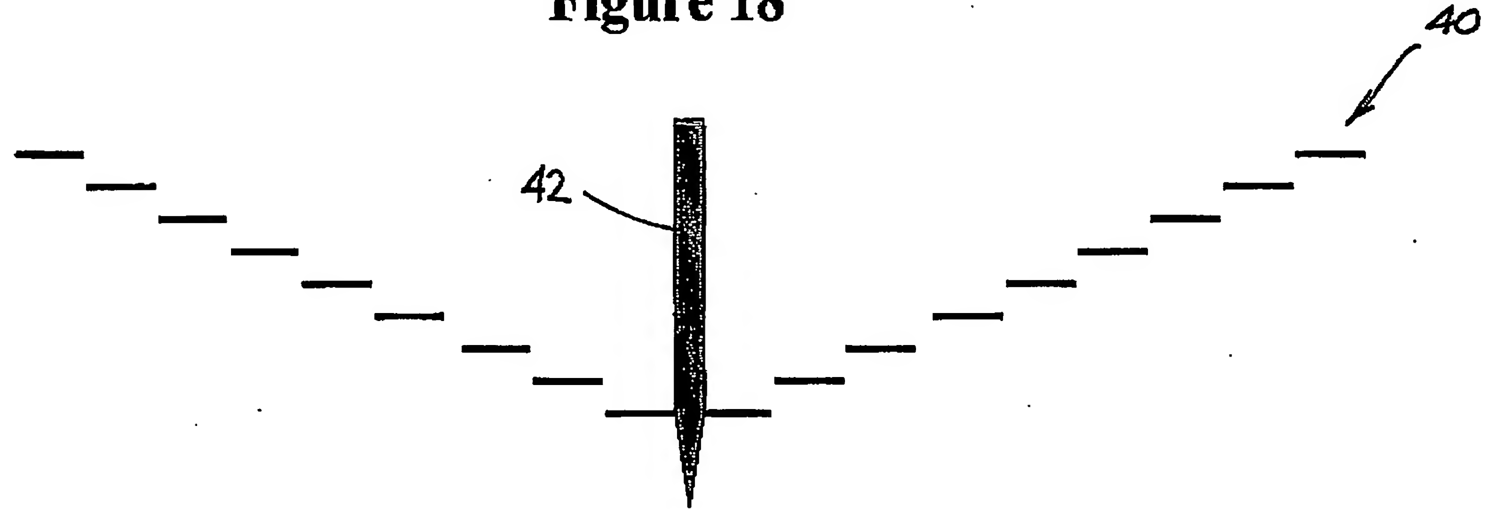


Figure 19

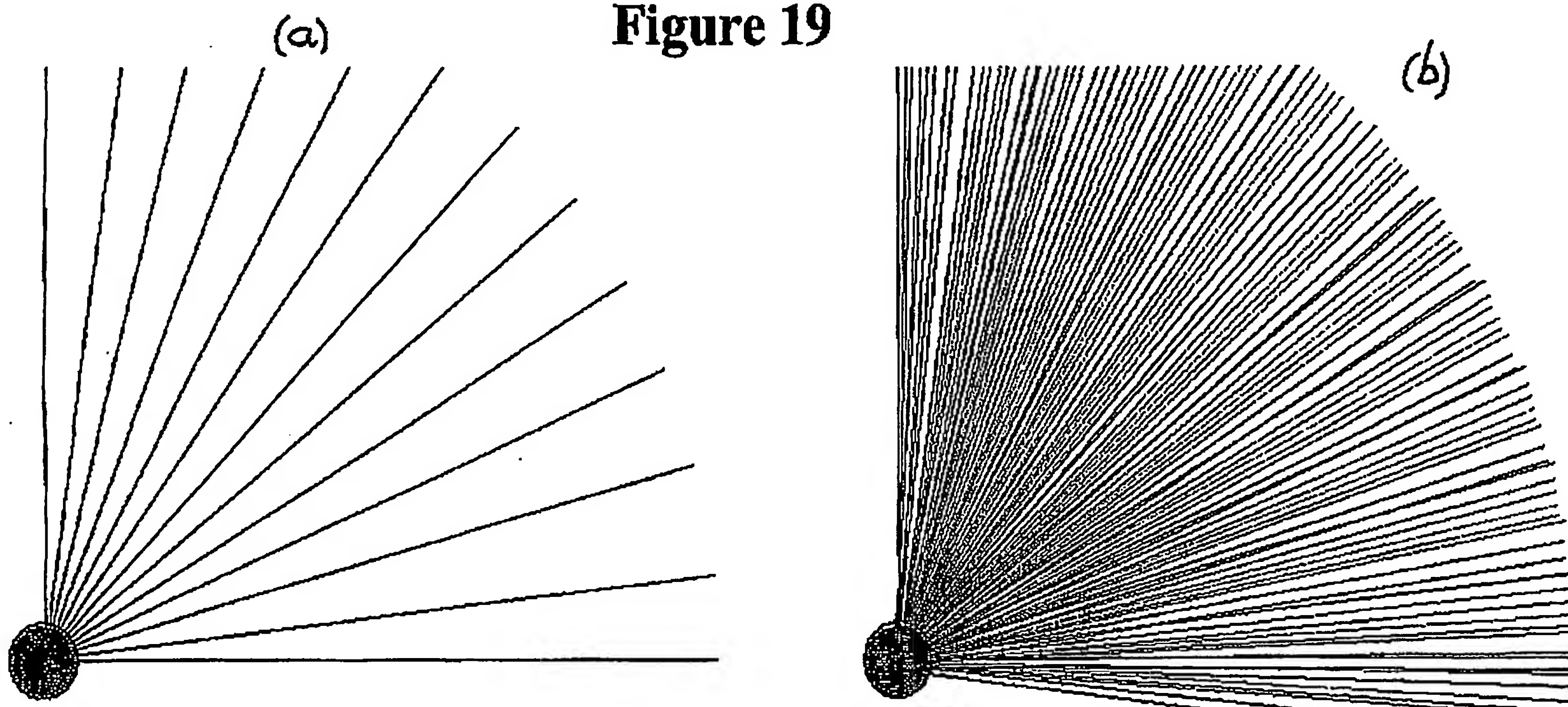


Figure 20

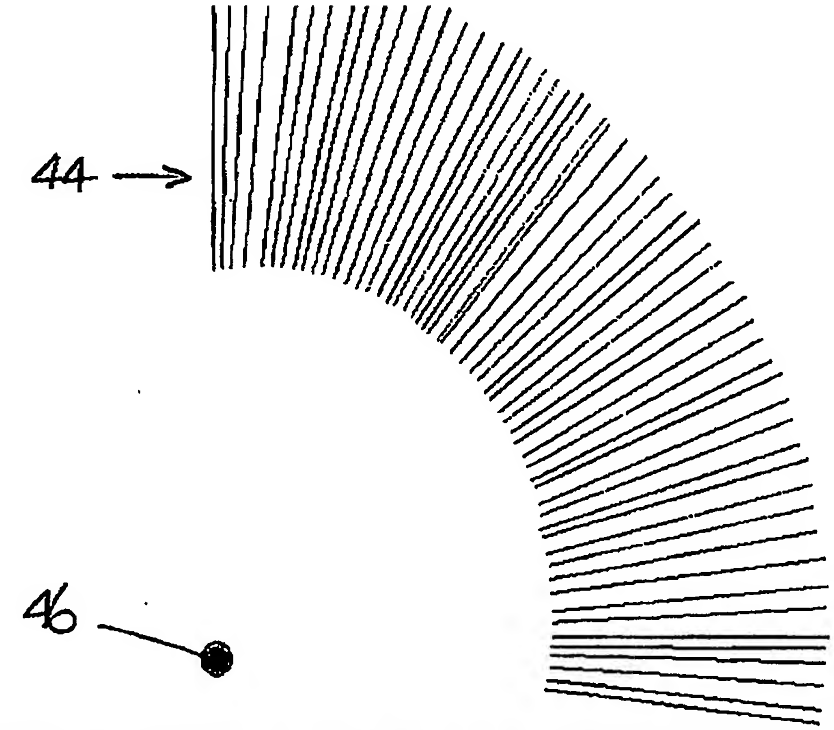


Figure 21

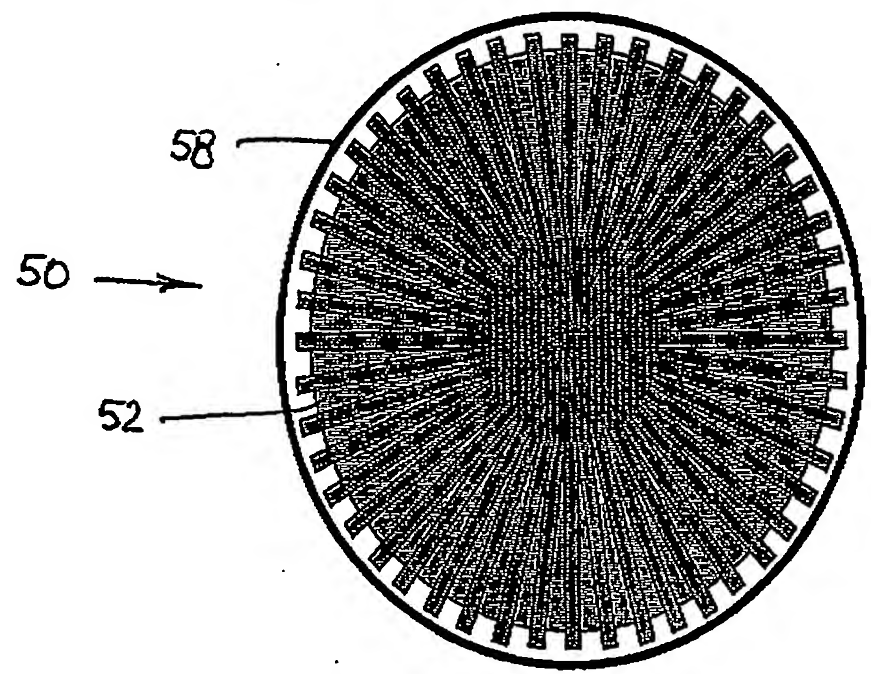


Figure 22

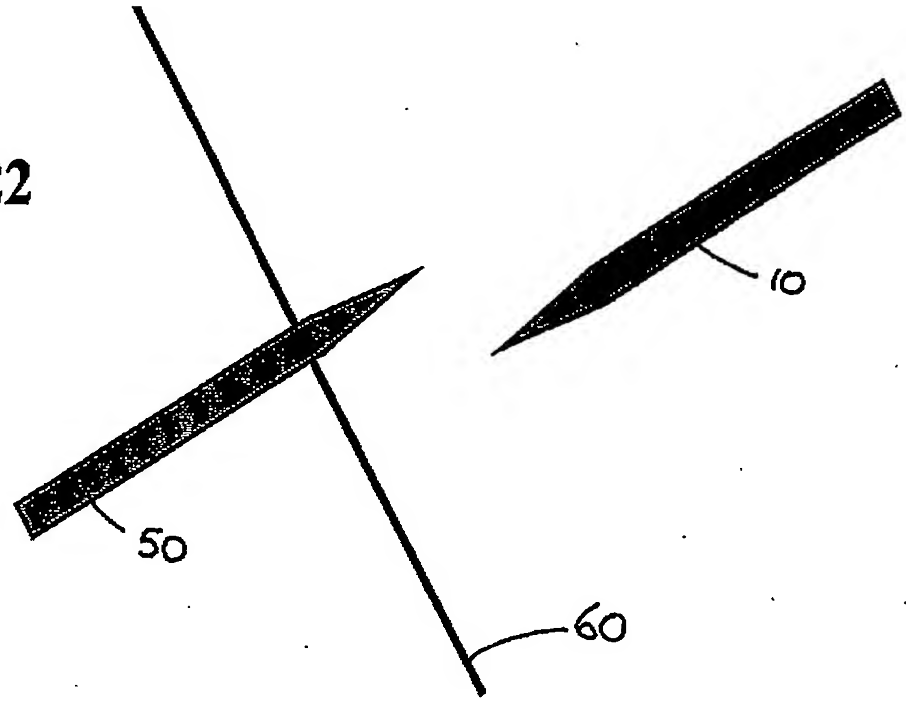


Figure 23

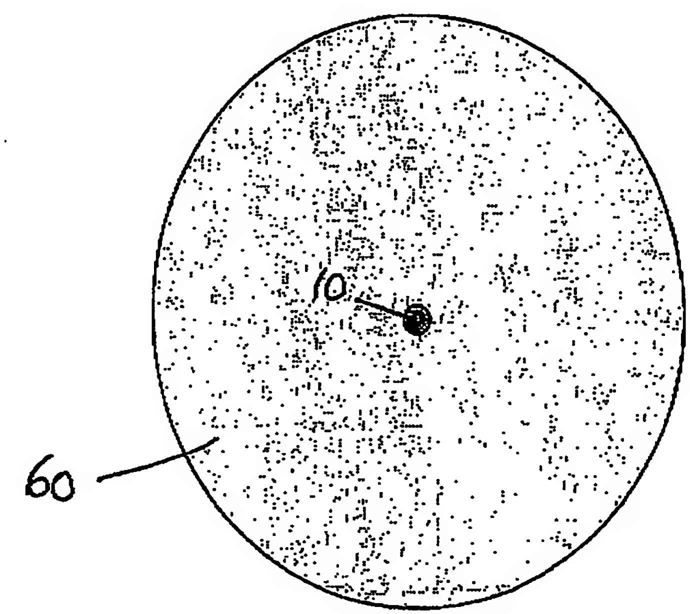


Figure 24

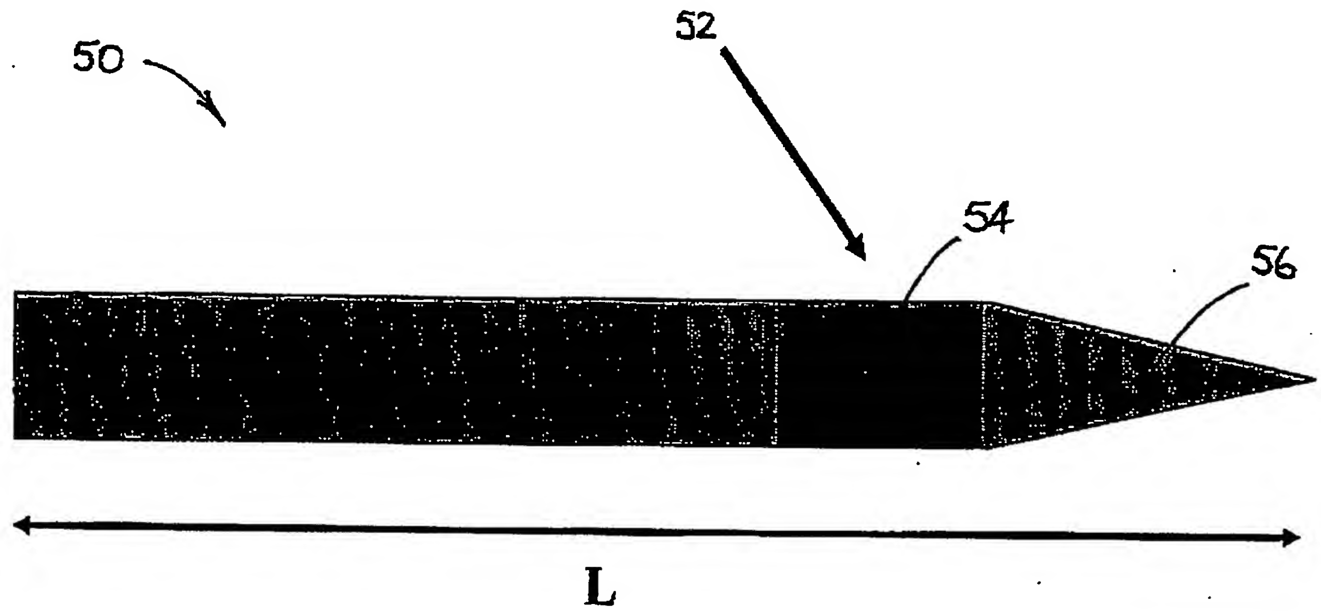
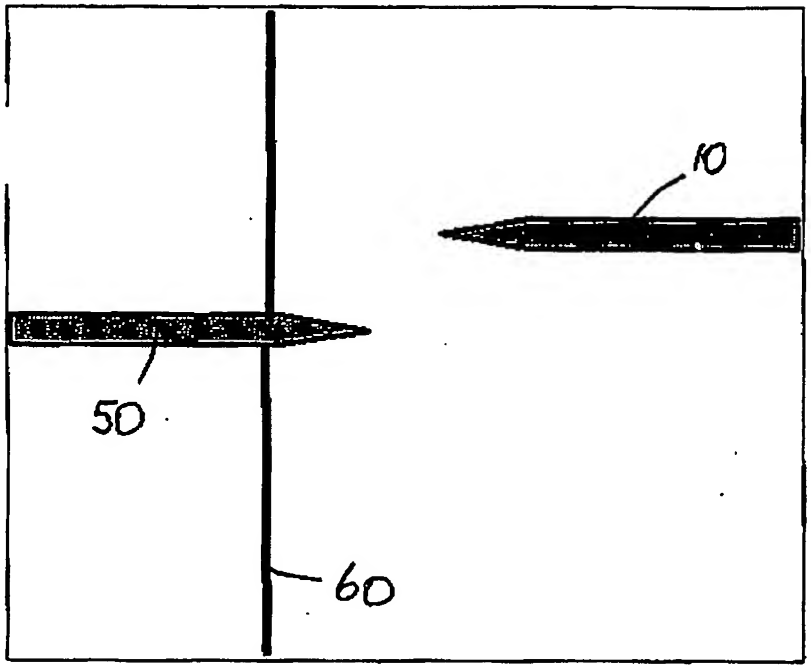


Figure 25a



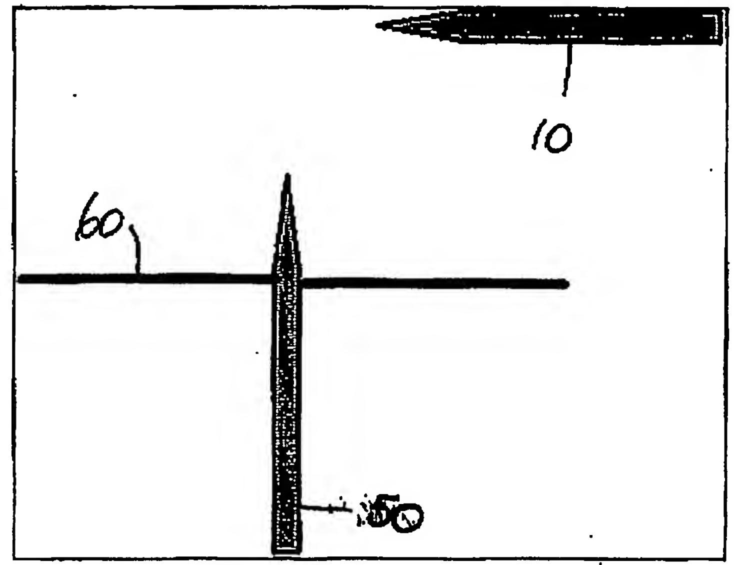


Figure 25b

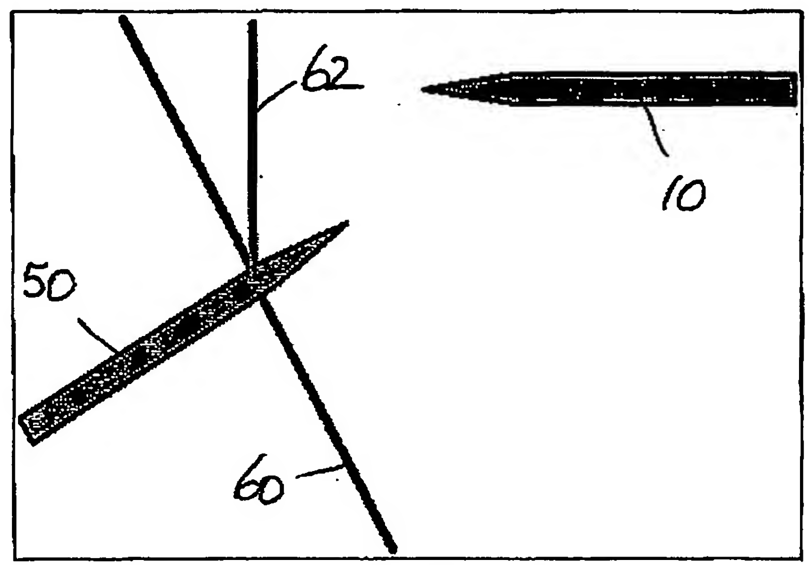
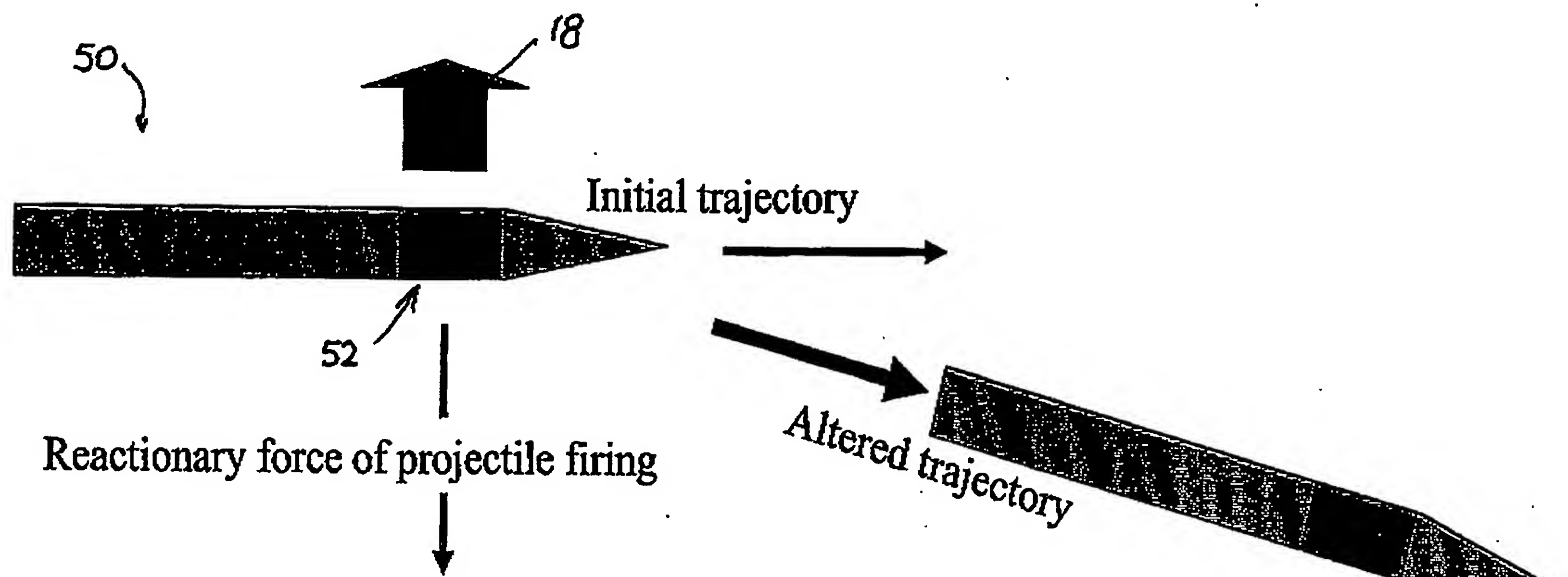


Figure 25c

Figure 26



50
18
Initial trajectory
52
Reactionary force of projectile firing
Altered trajectory

Figure 27

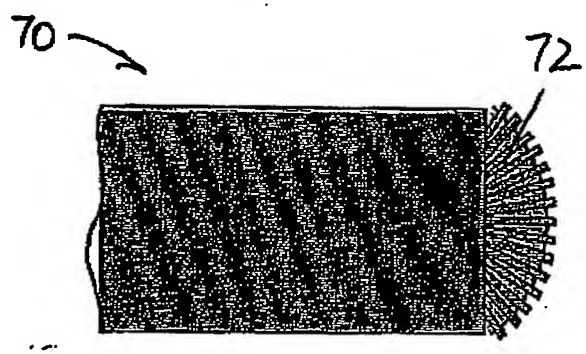
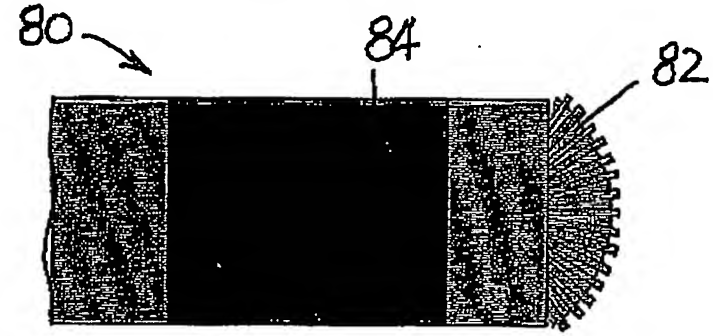


Figure 28



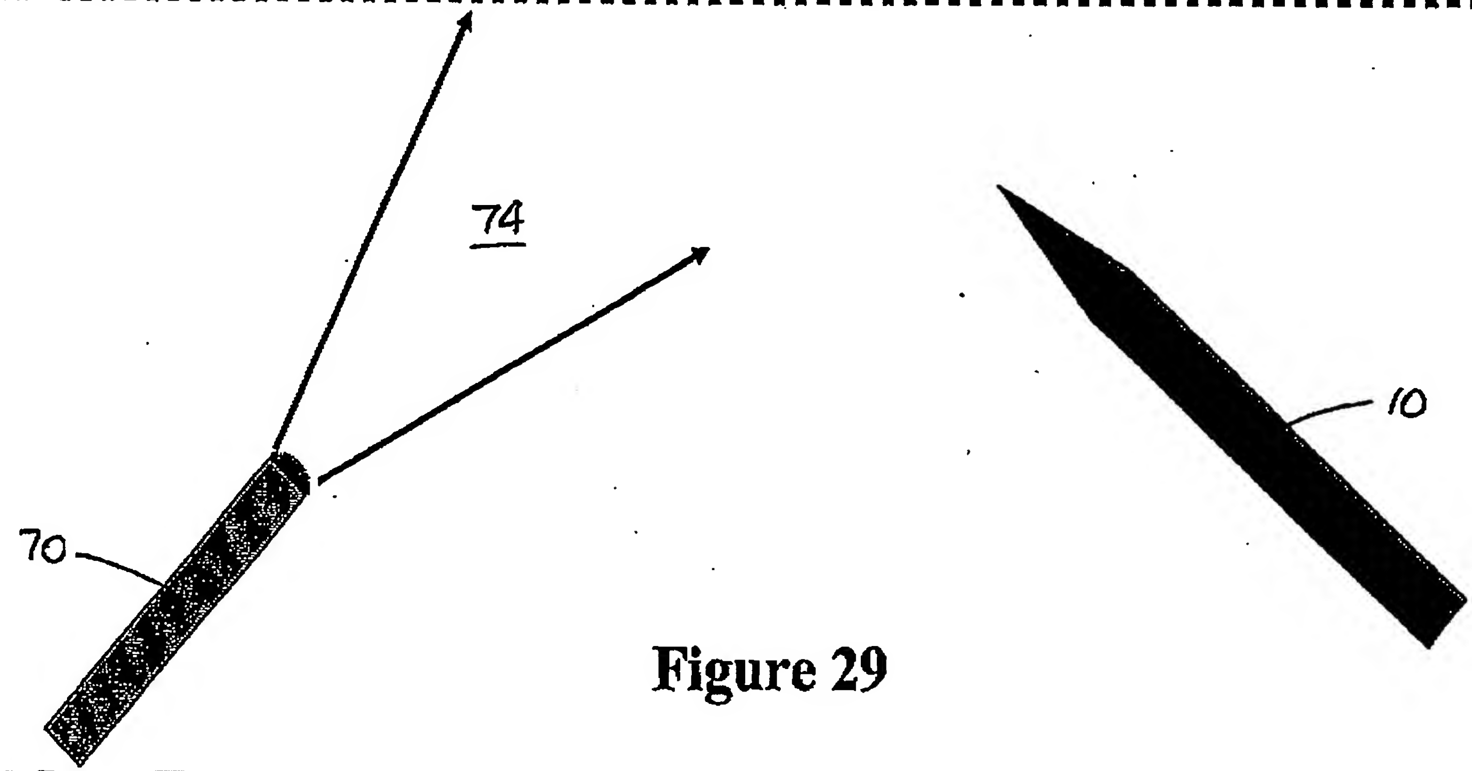


Figure 29